DOCUMENT RESUME

ED 025 725 AC 003 630

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Factors Related to the Adoption of Farm Practices.

Pub Date Feb 69

Note-25p.; Paper presented at the National Seminar on Adult Education Research (Toronto, February 9-11, 1969)

EDRS Price MF-$0.25 HC-$1.35

Descriptors-*Adoption (Ideas), Bibliographies, *Dairymen, *Factor Analysis, *Farm Management, Individual Characteristics, Information Sources, Research, *Rural Extension, Socioeconomic Status, Statistical Data

Dairy farmers (N=387) in two Pennsylvania counties were studied concerning their adoption of practices used on nearby demonstration farms. A total of 37 variables (including 11 "dummy variables") were used to measure personal characteristics, economic structures of farms, communication sources, and formal and informal participation. Factor analysis and multiple regression analysis were performed. Seven of the 37 variables accounted for 46% of the variance in adoption. Five of the seven variables (acreage farmed, farm equipment, participation in agricultural extension programs, participation in economic organizations, number of top twenty farmers talked to) were measures of formal participation, economic structure of farms, and communication sources. The farm equipment index explained over 20% of variance in adoption, which indicates that some processes are more applicable to larger, highly mechanized farms. None of the static personality characteristics was significant. (The document includes four tables, 48 references, and a brief research review.) (ly)

AC 003 630

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ED025725

Factors Related to the Adoption of Farm Practices

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The adoption of new ideas and technology represents an area of micro social change where an educational program has been used to diffuse the new ideas and technology. One illustration is the rapid diffusion of new farm practices in agriculture. Most of the scientific knowledge about new farm practices has come from the Colleges of Agriculture under the Land Grant College system. In the United States, teaching, research, and extension have been institutionalized in these colleges through legislation such as the Morrill Act, the Hatch Act, and the Smith Level Act.

The major purpose of this paper is related to the adoption of new farm practices among dairy farmers in two Pennsylvania Counties. Most of the empirical studies in sociology use a single variable model.[1] This study uses a multi-variable approach, using two complementary statistical techniques factor analysis and multiple regression analysis to determine factors related to adoption.

The educational program includes 17 unit demonstration farms in a program to instruct farmers in the value of new methods of farming.

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This project was sponsored by the Tenessee Valley Authority and the Cooperative Extension Service of The Pennsylvania State University. The use of a demonstration farm is itself an innovation as American demonstration farms follow the structure of the famous Moeckern Station in Germany.[2]

An innovation is defined in this study as an idea for accomplishing a certain goal.[3] This can be a new tool, a new technical process, or a new technology. Diffusion refers to the spread of the innovation in the social system.

Theoretical Framework and Literature Review

A number of empirical generalizations have been made from studies of farm practice adoption. In general, high adopters are younger, have more years of formal education, operate larger farms, participate more in formal organizations, and utilize more scientific sources of information about farm practices. Rogers,[4] identified five categories of variables used to explain and predict adoption. These are: Individual Attitudes, Nature of Business Operation, Social Structure, Group Relationships, and Communication Behavior. We will use this framework with only four categories because the data dées not have any variables relating to social structure of the farmer. We suggest that the four categories of variables which explain adoption are: Economic Structure of Farms, Personal Characteristics, Group Relationships, and Communication Sources.

The research tradition in adoption-diffusion is now multi-disciplinary with some 19 disciplines listed in the latest bibliography of diffusion studies.[5] In Rural Sociology, the tradition encompasses a period of more than half a century with an early study of 10,000 farmers who were asked about receiving agricultural bulleting and using information from them on their farms.[6] Forty-six percent of the studies in the 1967 bibliography are rural sociological studies, and 36 percent in 1968. The literature reviewed includes adoption of educational innovations, and studies in medical sociology about adoption of new drugs by doctors. Literature was reviewed in the areas of group relationships, economic factors, communication sources, and personal characteristics of adopters, and studies of adoption in non-Western countries.

Most of the empirical studies of farm practice adoption, and also in other areas such as education attempt to place respondents in adopter categories based on their acceptance or rejection of practices.[7] Adopters are categorized as laggards - last to adopt, late majority - next to last to adopt, early majority-- next to the first to adopt, and innovators who are first to adopt. This distribution follows the pattern of the normal curve. In general the innovators have more education, more years of formal education, participate more in organizations, and use more scientific sources of information. Rogers,[8] lists over fifty generalizations about adopters.

Personal characteristics such as age, education, and values have a positive or negative effect upon adoption. In the United States, age has a negative effect. It is easier for younger farmers to accept new ideas and change, and the older a farmer is the less likely he will adopt a new practice. Carlson,[9] studied school superintendents in Allegheny County, Pennsylvania and in West Virginia in order to find adoption patterns in school districts. Age was negatively associated with adoption of educational innovations as younger superintendents had adopted more practices than older superintendents. Copp,[10] in explaining the adoption of new practices of cattlemen in Kansas found that age was one of the four variables which explained most of the variance in adoption. Chaudai, Erickson, and Bajawa,[11] studied farm practice adoption in two Punjabi villages. Age had a positive relationship with adoption as younger farmers had low adoption scores. This may reflect the different cultural pattern where in the non-Western world young people are not given much responsibility for making decisions. Wilson,[12] found that farmers and their wives who had completed at least eight years of schooling had adopted twice as many new practices as those with less than eight years. The farmers self-perception about his role as an innovator has an influence on adoption. This has been demonstrated by Hrabouzsky and Moulik[13] in a study of the adoption of the Olpad Threhser in India, and Coughenour[14] who studied adoption of practices in 12 Kentucky Counties.

Much has been written about the effect of economic structures of farms on adoption. Ryan and Gross[15] in their study of the adoption of

hybrid seed in Iowa found that the number of acres that were seeded in corn was directly related to the use of the new hybrid seed. Carlson[16] found that high per pupil expenditure in the school districts of West Virginia and Allegheny County, Pennsylvania was not related to increased adoption of new educational innovations. School districts with low per pupil expenditure seemed to adopt as many new practices as those who had high expenditures per pupil. Size of cattle herd was positively related to adoption among cattlemen in Kansas[17]. Cancian,[18] in reviewing a number of studies about adoption concluded that the relationship between economic factors and adoption is curvilinear rather than linear. Middle income farmers seem to have higher rates of adoption than large farmers or small farmers. He suggests that these farmers realize they must compete in agriculture at a certain level, and immediate return on their investment in new practices is not a deterent to adoption. Kivlin and Fliegel,[19] observed the same relationship in a study of dairy farmers in Pennsylvania where the middle scale farmers did not seem to perceive economic risk as a deterent.

Increased productivity per man is also an indication of the economic factor. Rogers[20] in a study of Ohio farmers found that innovators had increased their productivity by using new technology. Measuring productive work units per man as an indicator, he found that innovators had an average of 614 work units per man, laggards only 159 work units per man. Dairy farming is becoming a specialized part of agriculture. Waters and Barr[21] in a study of dairy farmers in three Pennsylvania counties from 1942 to 1956 found that the average size of farm increased 18 percent

from 1942 to 1956, but productivity per man increased 2 1/2 times. Wallace,[22] in studying the farmers who dropped out of this study from 1962 to 1966 found that those who remained in dairying had more equipment than those who dropped out. Byrnes,[23] found that in the developing countries of the world, the farmer is not able to see the cause and effect relationship between plant disease and crop failure. Though farmers in these countries have low adoption scores, over 999 percent desired increased production from their crops.

The influence of group relationship is seen in the participation of the farmer in organizations, and the norms of the community. In the study of the Olpad Thresher in India, the village with the largest number of adopters was very heterogeneous. The other village with only three adopters was strongly influenced by the caste system. Young and Coleman,[25] found that in different neighborhoods of their study in Kentucky, the "successful farmers" had different adoption scores. In the high adopter neighborhoods, the "successful farmer" had a mean adoption score of 73. We see the opposite in the low adopter neighborhood where the "successful farmer" had a mean adoption score of only 37. Hofer[26] noted that cultural influences had a negative relationship upon adoption of new practices among celery growers in Michigan. Hagerstrand[27] observed the cluster effect of two practices, one relating to conservation of pasture, the other detection of tuberculosis in cattle. The two practices were first used by only a few farmers in one neighborhood, but soon spread to other neighborhoods. Hartman and Brown[28] did not find a spatial pattern in the adoption of farm practices in

Susquehanna County, Pennsylvania. Instead, they concluded that the spread of new practices reflected differing values of land in the county. Rogers and Van Den Bann[29] suggested that locality group influence is more important in the Netherlands than in the United States. Finley[30] in reviewing a number of studies on adoption found that in 11 of 13 studies, social participation is directly related to adoption. Ryan and Gross,[31] found that farmers who adopted new hybrid seed corn belonged to more organizations, participated more in these organizations, and attended more county fairs.

Different sources of communication are used at different times by adopters. Mason,[32] found that when farmers first thought of using tile drainage, the influence of their peers was most important. But, when they actually began to use the practice, they relied more upon the advice of technical experts. Sawhney,[33] in the study of Indian villages found that most of the Indian farmers depended upon personal sources of communication. Only 9.3 percent indicated thatmass media was an influence in adoption. McKendry, McKendry, and Parco,[34] studied rural people in the Philippines and found that government officials were chosen two-thirds of the time as sources of information. In farming and fishing areas, only 15 percent chose neighbors and friends as sources of information. Katz[35] noted differences between farmers and doctors in the use of communication sources. Salesman were chosen 49 percent of the time by farmers, but 57 percent of the time by doctors. Hovland, Jarvis, and Kelly[36] noted that an important factor influencing the effectiveness of a communication is the perception the receiver has of the communicator.

Diffusion is sometimes hastened by external sources, and most studies seem to ignore this aspect of diffusion. This is sometimes called the "halo" effect. Radar moved quickly from the laboratory to the operational arena due to the influence of Sir Harry Tizard who recognized it as a defensive weapon against enemy bombers. Even though England was not at war in 1936, the first operational trials were held that year and by 1940 a chain or radar stations was already in operation.[37] Racial Integration was accomplished in the armed forces by executive order of President Truman in 1948. Ryan and Gross (1950),[38] noted that it was advantageous for Iowa Farmers to use hybrid seed corn because of acreage limitations under the AAA program of the New Deal. Even though acreages were reduced, the same amount of corn per acre if nor more, could be realized by using hybrid seed because of increased yields. Brickell[39] found that the rate of adoption of educational innovations in New York State doubled in the 15 months after Sputnik was launched. The use of PPBS as an innovation in government planning was first used in the Defense Department under Secretary McNamara, but was later made mandatory in all agencies of the federal government by executive order of President Johnson in 1965.[40]

Methodology

A sample of dairy farmers was chosen in two counties of Pennsylvania. These farmers lived contiguous to the 17 unit demonstration farms within a radius of 7 miles. The Benchmark Study in 1962 included 638

farmers. In the Terminal Study in 1966, 387 farmers were interviewed; 253 had dropped out of farming in the interim. We have used data for this paper from the 387 who were in business in 1962 and 1966, using principally the 1962 data. Of the 387 farmers, 148 were in one county, and 239 were in the other.

In each of the two counties, the average size milking herd was 28 cows per farm, but farm size differed. In one county farms averaged 236 acres per farm, in the other, 165 acres per farm. Average age of the farmers in the two counties was 50 years. Farm families constitute 9 percent of the population in one county, and 20 percent in the other.

The dependent variable is a Farm Practice Index composed of 19 practices used on the demonstration farms. (See Figure 1) The 19 practices were chosen from a total of 40 practices demonstrated on these farms because of their ability to discriminate between high and low scoring points through Trace Line Analysis (Copp).[41] The Trace Line Analysis is a technique that presumes if an item is a constant indicator of a latent variable, in this case the farmers predisposition to adopt new practices, the proportion of subjects will increase monotonically as the strength of the latent variable increases. Thus when items monotonically related to the latent variable are combined in a scale or index the number of items which respondents can identify can be taken as an indicator of his position on the latent variable continuum. The index was adjusted to each farm. If a farm did not have any permanent pasture, then items relating to permanent pasture were not

used in computing the index score. Range of possible scores on the index was 0-1, with a mean score of .406 and a standard deviation of .177.

Thirty-seven independent variables were used to measure personal characteristics, economic structure of the farm, communication sources, and formal and informal participation. Eleven of the 37 independent variables are "dummy variables."[42] Qualitative Data can be quantified by using this technique if the categories of the variable are dichotomized as one or zero. If a respondent fits the category of the dummy variable, he is given a score of one, if not, a score of zero. Coefficients generated by the "dummy variables" apply only to the category of the dummy variable that is related to the original variable. We have used farm income as a dummy variable because data was collected using the six categories of farm income in the Agricultural Census. The other five variables are responses to measure values and were used by Folkman,[43] in a study of Arkansas Farmers.

Most empirical studies use a single variable model. This analysis indicates direction and intensity of association between the independent variable and the dependent variables without taking into account the influence of the other independent variables. We used a multiple analysis model using two statistical techniques, Factor Analysis and Multiple Regression Analysis. Our objective was to identify the factors related to adoption.

Factor Analysis,[44] is used to identify clusters of independent variables that indicate some latent dimension. This method examines intercorrelations between pairs of variables. With a given number of variables n, then there are $\frac{n(n-1)}{2}$ possible pairs of variables. The technique has been used by psychologists in determining tests that measure a given latent dimension such as I.Q., Verbal Ability, Mathematical Skills, etc. We have used a Principal Component Analysis with Varimax Rotation[45] in a program written for the IBM 360 computer. The factor matrices were rotated so that a given set of factors can be obtained which have the property of being highly correlated with some indices, but uncorrelated with others.

A Multiple Regression Least Squares Analysis was used to determine the influence of the 37 independent variables upon the dependent variable. In the regression equation $Y=a+b_1x_1 + b_2x_2 + b_3x_3 \ldots + b_kx_k$, where Y represents the amount of change in the dependent variable that can be associated with a given unit of change in the dependent variable, the remaining variables held constant.[46] The Multiple Correlation Coefficient, R^2 indicates the amount of total variances that is explained in the dependent variable by the independent variable. The F ratio indicates the statistical significance of the relationship.

We have used a step wise least squares option in Multiple Regression[47] in order to find which of the variables account for most of the explained variance in the dependent variable. This is a process by which the size of the Student T value is used to indicate the

relationship between given independent variables and the dependent variable. The Student T value is used in a iterative process to eliminate those variables for which probability of relationship was less than the specified minimum.

Findings

Five factors were called for in the computer program. (See Table 1) Seven of the variables load high in Factor I. These variables are chosen in this factor and in all the other factors because they have a factor loading of + or -.50. Factor loadings refer to the correlations between a given index and a factor. Four of the seven variables measure participation: Leadership in Economic Organizations, Formal Participation in Social Organizations, Leadership in Social Organizations, and Participation in Agricultural Extension Programs. The other three measure communication sources; Top 20 Farmers Talked to, Top 20 Farmers talked to about farming, and Interaction Index. The 37 variables in this factor account for .64 percent of the variance.

In Factor II, only four variables reached the required .50 loading. These are all measures of Economic structure of farms; Milking Herd Size, Farm Equipment Index, Acres Farmed, Gross Farm Sales $20,000 to $39,999. Factor II accounts for .22 percent of the variance.

Factors III, IV, and V do not seem to add much to our analysis. Factor III seems to be a less satisfactory factor because of the

clustering of variables which load .50 or higher; Formal Participation in Economic Organizations (also loads .40 in Factor I, Goal - Free of Debt, Number of Dailies Received, and Percent of Gross Income from Dairy Operation. Because the variable Participation in Economic Organizations has a loading of .50 in Factor I, then it may be possible that this variable is not unidimensional. For all meaningful purposes we have isolated only two meaning factors of 11 variables. Factor I seems to measure a latent dimension of Participation-Communication, while Factor II measures Economic STructure of the Farm. Two variables which load high in Factor I, Top 20 Farmers talked to, and Top 20 Farmers talked to about farming are very highly intercorrelated (r=.95).

In the Multiple Regression Analysis see (Table 3) the 37 independent variables accounted for 49 percent of the total variance in the dependent variable. The F ratio is significant at the .001 level. When the Step Wise Least Squares (See Table 4) option is used, only seven of the 37 remain, and these account for 46 percent of the explained variance in the dependent variable. Two of these variables measure personal characteristics; Self Image of Adoption, and Satisfaction With Accomplishments. Two are measures of economic structure of farms; Acreage Farmed, and Farm Equipment Index. Two are measures of Participation; Participation in Economic Organizations, and Participation in Agricultural Extension programs. One is a measure of communication sources, Number of Top 20 Farmers talked to. One variable, Farm Equipment Index, accounts for 20 percent of the variance in the

dependent variable.[48] By adding 30 variables, we increase the amount of explained variance only 3 percent.

Conclusions

Our objective was to use two complementary statistical techniques to identify factors related to adoption of farm practices. Thirty-seven independent variables were used to measure formal and informal participation, communication sources, economic structure of farms, and personal characteristics. Through Factor Analysis, we identified two factors containing 11 variables. Factor I is labeled Leadership-Communication, and Factor II, Economic Structure of Farms. By proposition the independent variables are related to the dependent variable in this analysis. While Factor Analysis is of value in identifying cluster of independent variables that measure a latent dimension, or objective was to identify the factors or variables which explain adoption. This was done through Multiple Regression Analysis with a Step Wise Least Squares option. Seven of the 37 variables account for 46 percent of the total explained variance in the dependent variable. By adding 20 variables, we increase the rate of explained variances only 3 percent.

Five of the seven variables identified in the Multiple Regression Analysis loaded high in Factors I and II. These are measures of formal participation, and economic structure of farms. By looking at the clusters of variables in the Factor Analysis we can identify variables

that are highly interrelated. Such variables identify a latent variable. The two variables that did not load high in any factor are measures of personal characteristics; Self Image of Adoption, and Satisfaction with Accomplishments. Though these were not identified in the Factor Analysis, the Multiple Regression Analysis indicates that these variables are related to the dependent variable are independent of the other variables.

One variable in the regression analysis, Farm Equipment Index accounts for over 20 percent of the explained variance in the dependent variable. This would indicate that some practices are more applicable to larger farms which are highly mechanized. It is interesting that no static personal characteristics such as age and education have been identified as important variables. In most adoption studies, both of these are very highly related to adoption.

Figure 1. Farm Practice Index

1. Use of complete soil test for each pasture field at least once every three years.
2. Use of complete soil test for each crop field at least once every three years.
3. Regular use of lime on pastures.
4. Regular use of lime on crop field.
5. Use of fertilizer on pasture fields.
6. Use of fertilizer on other crops.
7. Topdressing of hay or legumes.
8. Use of alfalfa and/or trefoil as a grass crop.
9. Band seeding of grasses.
10. Use of spray for leaf hoppers and/or spittle bugs
11. Use of spray for alfalfa weevil
12. Sowing legumes without a nurse or cover crop
13. Use of forage testing.
14. Use of atrazine for weed control on corn.
15. Use of side band placement attachment on corn planters.
16. Planting corn after corn on the same ground.
17. Use of stable ventilation fan.
18. Keeping of adequate farm records.

Computed for each farmer and adjusted for his farm operation.

$\bar{X} = .406$
$S = .177$

FOOTNOTES

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National Seminar on Adult Education
Toronto, Canada

February 9-11
1969

Not for Publication

AE003630

Table 1. Rotated Matrix of Factor Loadings.

Variable	I	II	III	IV	V	h^2
Acres farmed	.130	-.744	.205	-.074	-.019	.618
Herd size	.092	-.867	-.043	-.126	.018	.779
Formal participation econ.	.409	-.050	-.520	.009	.211	.485
Leadership index econ.	.613	-.063	-.114	-.021	.037	.394
Formal participation soc.	.554	-.144	-.023	-.144	-.237	.406
Leadership index soc.	.555	.160	-.115	-.126	-.085	.371
Number dailies received	.047	-.070	-.547	.126	-.025	.323
Number top 20 farmers talked to	.854	-.215	-.012	.061	.005	.781
Rationality index	.315	-.251	-.360	-.237	.110	.360
Informal participation	.432	-.169	-.321	-.338	.003	.434
Number children at home	.077	-.121	-.076	-.550	-.030	.331
Age	.028	.186	-.082	.752	-.149	.630
Education	.258	-.247	.110	-.531	-.017	.423
Household convenience index	.296	-.378	-.329	-.211	-.040	.386
How feel about farming five years from now	.139	-.296	-.262	-.267	.275	.323
Satisfaction with accomplishments as a farmer	.105	-.268	-.299	.282	-.000	.252
Interaction index	.778	-.221	.041	.034	.034	.659
Extension participation index	.613	-.155	-.139	-.127	.054	.439
*Goal 1st - Free of debt	-.039	-.066	.502	.429	.207	.486
*Goal 1st - Good education for children	.104	-.079	-.295	-.325	-.774	.810
*Goal 1st - Modern household conveniences	-.009	.139	-.214	-.166	.679	.553
Self evaluation of adoption	-.262	.336	.206	.200	-.036	.267
Percent gross income from dairying	.062	-.156	.712	-.067	-.100	.550
Number top 20 farmers talked to about farming	.865	-.202	-.013	.045	.040	.793
*Gross sales under $2,500	-.030	.243	.202	-.308	.008	.196
*Gross sales $2,500 to $4,999	-.074	.299	.108	.269	-.396	.336
*Gross sales $5,000 to $9,999	-.082	.400	-.124	.034	.315	.283
*Gross sales $20,000 to $39,999	.173	-.470	-.012	-.116	.048	.267
*Gross sales over $40,000	.021	-.441	-.088	.019	-.058	.006
Membership in Pennsylvania Farmers	-.229	.263	.368	.029	-.220	.307
Farm equipment index	.204	-.596	-.398	-.190	.016	.591
Eigenvalues	.64	.22	.21	.16	.15	

*Dummy Variables

Variables chosen because of a zero-order correlation value of $\neq$ .100

Table 2. Zero-Order Correlation Coefficients and Dependent Variable is Farm Practice Index.

Variable	r
Acres farmed	.115
Herd size	.326
Formal participation econ.	.415
Leadership index econ.	.277
Formal participation soc.	.203
Leadership index soc.	.161
Number dailies received	.202
Number top 20 farmers talked to	.366
Rationality index	.423
Total informal participation	.397
Number children at home	.134
Number children available for work	.057
Age	-.167
Education	.209
Household convenience index	.297
How feel about farming five years from now	.294
Satisfaction with accomplishments	.215
Interaction index	.278
Extension participation index	.427
*Goal 1st - Free of debt	-.282
*Goal 1st - Good education for children	.168
*Goal 1st - Having children marry and live near by	.069
*Goal 1st - Modern farm equipment	.148
*Goal 1st - Modern household consequences	-.039
Self evaluation of adoption	-.394
Evaluation of neighborhood	-.039
Percent gross income from dairying	-.249
Number top 20 farmers talked to about farming	.358
Number of weeks worked off farm	.014
*Gross sales under $2,500	-.131
*Gross sales $2,500 to $4,999	-.226
*Gross sales $5,000 to $9,999	-.106
*Gross sales $10,000 to $19,999	.079
*Gross sales $20,000 to $39,999	.263
*Gross sales over $40,000	.171
Membership in Pennsylvania Farmers	-.278
Farm equipment index	.551

*Dummy Variable

.100 Significant at .05 level
.131 Significant .01 level

Table 3. Multiple Regression Analysis is 37 Independent Variables and Farm Practice Index is the Dependent Variable.

Variable	Beta Weight
Acres farmed	-.139
Milking herd size	.020
Formal participation econ.	.181
Leadership index econ.	-.006
Formal participation soc.	.001
Leadership index soc.	.001
Number dailies received	.028
Number top 20 farmers talked to	.280
Rationality index	.080
Total informal participation	.050
Number children at home	.001
Number of children available for work	-.040
Age	-.056
Education	.042
Household convenience index	-.084
How feel about farming five years from now	.003
Satisfaction with accomplishments as a farmer	.088
Interaction index	-.100
Extension participation index	.213
*Goal 1st - Free of debt	-.310
*Goal 1st - Good education for children	-.263
*Goal 1st - Having children marry and live near by	-.069
*Goal 1st - Modern farm equipment	-.191
*Goal 1st - Moder household conveniences	-.037
Self evaluation of adoption	-.124
Evaluation of neighborhood	.075
Percent gross sales from dairying	-.061
Number top 20 farmers talked to about farming	-.159
Number weeks worked off farm	-.018
*Gross sales under $2,500	-.025
*Gross sales $2,500 to $4,999	-.019
*Gross sales $5,000 to $9,999	.021
*Gross sales $10,000 to $19,999	.035
*Gross sales $20,000 to $39,999	.097
*Gross sales over $40,000	.111
Membership in Pennsylvania Farmers	.050
Farm equipment index	.318

Multiple R^2 Corrected for Degrees of Freedom = .49

F Ratio = 11,207** 37 and 349 Degrees of Freedom

*Dummy Variable
**Significant at .001 level

Table 4. Step Wise Least Squares Regression Analysis

Variable	Beta ~~Coefficient~~ Weight
Acres farmed	-.099
Formal participation econ.	.190
Top 20 farmers talked to	.067
Satisfaction with accomplishments	.096
Extension participation index	.199
Self evaluation of adoption	-.146
Farm equipment index	.393

Multiple R^2 Corrected for Degrees of Freedom = .46

F Ratio = 48.658** 7 and 379 Degrees of Freedom

**Significant at .001 level

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